Title: Lessons for Interstellar Travel from the Guidance and Control Design of the Near Earth Asteroid Scout Solar Sail Mission

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Background

NASA's Near Earth Asteroid Scout (NEA Scout) solar sail mission will fly by and image an asteroid. The team has experience characterizing the sail forces and torques used in guidance, navigation, and control to meet the scientific objectives. Interstellar and precursor sail missions similarly require understanding of beam riding dynamics to follow sufficiently accurate trajectories to perform their missions.

Objective

Identify the driving factors required to implement a guidance and control system that meets mission requirements for a solar sail mission. Compare experience of an asteroid flyby mission to interstellar missions to flyby and observe other stars or precursor missions to study the extrasolar medium.

Methods

The NEA Scout team combined mechanical design, sail film optical testing, and finite element modeling into a model of solar force and torque as a function of illumination angles. An interstellar sail will require a similar model for beam illumination. The torque model used for attitude control will be updated after deployment by steering to different angles and observing reaction wheel momentum accumulation. The force model used for navigation will be updated by observing the orbit perturbation during the early mission.

Interstellar sails also require accurate force and torque knowledge. Stable attitude and position prevent the sail from flipping over or drifting out of the beam. Even if the sail is stable, off-nominal attitude and position oscillations could reduce the average thrust and lead to the trajectory being too far off-course. Accurate modeling before launch will ensure that the sail design is sufficient to achieve the mission. On-orbit testing and updating the force and torque models may ensure that guidance to the beam and sail result in the required trajectory.

Results

Design details like the sail shape and optical properties have a large effect on the torque model of the sail. Sail torques drive the attitude control system design. For an interstellar sail, torques drive the dynamics of riding a beam and meeting interstellar navigation requirements.

Conclusions

The exercise of designing a solar sail science mission to visit an asteroid are instructive for understanding how to design interstellar sails with beam propulsion.